Ultra High Temperature (UHT) SiC Fiber

Principal Investigator: J. A. DiCarlo / GRC-LM
Team Members: N. Jacobson / GRC-LME; M. Lizcano / GRC-LMN; R.T. Bhatt / OAI-GRC-LMC

Abstract

Silicon-carbide fiber-reinforced silicon-carbide ceramic matrix composites (SiC/SiC CMC) are emerging lightweight re-usable structural materials not only for hot section components in gas turbine engines, but also for control surfaces and leading edges of reusable hypersonic vehicles as well as for nuclear propulsion and reactor components. It has been shown that when these CMC are employed in engine hot-section components, the higher the upper use temperature (UUT) of the SiC fiber, the more performance benefits are accrued, such as higher operating temperatures, reduced component cooling air, reduced fuel consumption, and reduced emissions. The first generation of SiC/SiC CMC with a temperature capability of 2200-2400ºF are on the verge of being introduced into the hot-section components of commercial and military gas turbine engines.

Today the SiC fiber type currently recognized as the world's best in terms of thermo-mechanical performance is the "Sylramic-iBN" fiber. This fiber was previously developed by the PI at NASA GRC using patented processes to improve the high-cost commercial "Sylramic" fiber, which in turn was derived from another low-cost low-performance commercial fiber. Although the Sylramic-iBN fiber shows state-of-the art creep and rupture resistance for use temperatures above 2550^{o}F, NASA has shown by fundamental creep studies and model development that its microstructure and creep resistance could theoretically be significantly improved to produce an Ultra High Temperature (UHT) SiC fiber.

This Phase II Seedling Fund effort has been focused on the key objective of developing a UHT SiC fiber by effectively repeating the similar processes for producing the Sylramic-iBN fiber using a design of experiments approach to first understand the cause of the less than optimum Sylramic-iBN microstructure and then attempting to develop process conditions that eliminate or minimize these key microstructural issues. In so doing, it is predicted that that these advanced processes could result in an UHT SiC fiber with >20 times more creep resistance than the Sylramic-iBN fiber, which in turn would allow SiC/SiC CMC to operate up to 2700^{o}F and above, thereby further enhancing the performance benefits of SiC/SiC components in aero-propulsion engines. It was also envisioned that the fiber processes developed during Phase II efforts would not only reduce production costs for the UHT fiber by combining processes and using low-cost precursor fibers, but also could allow the UHT fibers to be directly produced in preforms of the precursor fibers, possibly at the facilities of the CMC fabricator. This presentation details current progress towards these objectives.